

# Overview

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## Overview

### Key Issues

Important energy issues addressed in the *Annual Energy Outlook 2000* (AEO2000) include, among others, the ongoing restructuring of U.S. electricity markets, near-term prospects for world oil markets, and the impacts of energy use on carbon emissions.

AEO2000 reflects the restructuring of U.S. electricity markets and the shift to increased competition by assuming changes in the financial structure of the industry. Ongoing efficiency and operating improvements are also assumed to continue. The projections assume a transition to full competitive pricing in States with specific deregulation plans—California, New York, New England, the Mid-Atlantic States, Illinois, Texas, Michigan, Ohio, Arizona, and New Mexico. Other States are assumed to continue cost-of-service electricity pricing. The provisions of the California legislation regarding stranded cost recovery and price caps are included. In other regions, stranded cost recovery is assumed to be phased out by 2008.

A national renewable portfolio standard has been proposed in the Comprehensive Electricity Competition Act, but it has not been enacted and is not included in the projections. State standards are included as enacted. Although AEO99 included new proposed standards for control of nitrogen oxide (NO<sub>x</sub>) by electricity generators, those standards have been challenged in court, are currently suspended, and are not included in AEO2000.

World oil prices fell sharply throughout most of 1997 and 1998, in part because of the economic recession in East Asia. Recently, economic recovery in that region and actions by the Organization of Petroleum Exporting Countries (OPEC) to restrain oil production have resulted in higher world oil prices, which are included in the oil market analysis and world oil price projections in AEO2000.

Although growth in carbon emissions in 1998 was slower than in previous years, emissions are projected to remain at levels similar to those projected in AEO99, as the demand for energy continues to grow.

### Prices

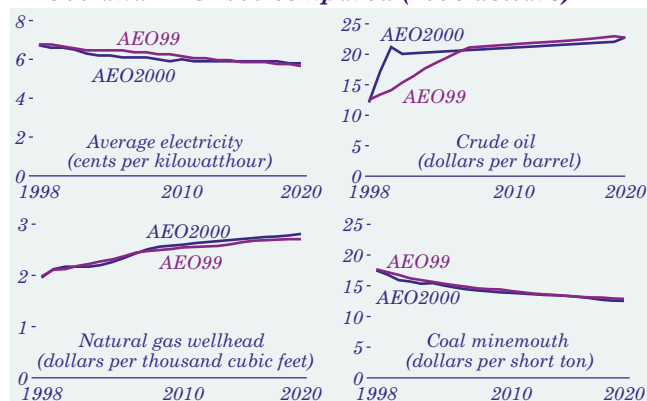
Average world crude oil prices in AEO2000 increase from about \$12.10 a barrel (all prices in 1998 dollars) to \$22.04 a barrel in 2020 (Figure 1), nearly \$1 a

barrel lower than the price of \$22.99 projected in AEO99. Price projections over the next several years are much higher than in AEO99, by about \$7 a barrel in 2000. Higher near-term prices are projected as a result of the economic recovery in East Asia, which has occurred at a more rapid pace than projected in AEO99, and the March 1999 agreement by OPEC and four non-OPEC countries to cut oil production, which appears to be holding.

Lower world oil price projections for 2020 result from three factors. First, higher near-term prices stimulate drilling activity and increase production potential. Second, lower long-term economic growth is projected for the Pacific Rim. Finally, it appears likely that non-OPEC oil production will be higher than previously projected due to technology improvements, particularly for offshore production.

Worldwide demand for oil is expected to increase from 75.0 million barrels per day in 1998 to 112.4 million barrels per day in 2020, slightly lower than the AEO99 projection of 114.7 million barrels per day. The potential for production increases in both OPEC and non-OPEC nations leads to relatively low growth of prices through 2020, although the demand for oil grows rapidly. OPEC oil production is expected to reach 55.5 million barrels per day in 2020, nearly double the 31.7 million barrels per day in 1998, assuming sufficient capital to expand production capacity. It is assumed that the United Nations resolution limiting Iraqi oil exports will remain in place until 2002. Once sanctions are lifted, Iraqi oil production is expected to reach 4.0 million barrels per day within 2 years and about 6.0 million barrels per day within a decade. Outside the Persian Gulf, production is expected to grow in the offshore regions of Nigeria and Algeria and in Venezuela.

**Figure 1. Fuel price projections, 1998-2020: AEO99 and AEO2000 compared (1998 dollars)**



Non-OPEC oil production is expected to increase from 44.3 million barrels per day in 1998 to 56.6 million barrels per day in 2020—1 million barrels per day higher than in *AEO99*. Production from the Caspian Basin is expected to reach 6 million barrels per day, resulting in a near doubling of production in the former Soviet Union by 2020, with continuing expansion of production from the North Sea and the offshore regions of West Africa. Both Brazil and Colombia are expected to produce 1 million barrels per day early in the next decade, and production in Mexico and Canada is also likely to increase.

The average U.S. wellhead price of natural gas is projected to increase from \$1.96 per thousand cubic feet in 1998 to \$2.81 per thousand cubic feet in 2020, at an average rate of 1.7 percent a year. Improvements in exploration and production technologies for natural gas moderate additional price increases. In 2020, the price is \$0.10 per thousand cubic feet higher than projected in *AEO99*, even with slightly lower demand, because low prices tend to dampen reserve additions in the near term. Average delivered prices increase by 0.4 percent a year from 1998 to 2020. Although average transmission and distribution margins are about \$0.10 per thousand cubic feet higher than in *AEO99*, the projected margins in the residential and commercial sectors are higher by about \$0.30 to \$0.50 because of an increase in projected capital costs and fewer cost reductions from efficiency improvements than previously assumed.

In *AEO2000*, the average minemouth price of coal in the United States is projected to decline from \$17.51 a ton in 1998 to \$12.54 a ton in 2020. The price declines through 2020 due to increasing productivity in the industry, a shift to lower cost western production, and competitive pressures on labor costs. Compared with *AEO99*, coal production is lower later in the projection period, and higher productivity, particularly in the Powder River Basin, is assumed. As a result, the average coal price is lower than the \$12.89 a ton projected in *AEO99* for 2020.

Average electricity prices decline from 6.7 cents per kilowatthour in 1998 to 5.8 cents per kilowatthour in 2020, an average annual decline of 0.6 percent. Because competitive markets are assumed in more regions of the country than in *AEO99*, average prices are lower in *AEO2000* in the earlier years of the projections. In 2020, the price is slightly higher than the 5.7 cents per kilowatthour projected in *AEO99*

because of the assumed higher cost of capital and a slower decline in the capital costs of natural gas generation in the later years. The restructuring of the electricity industry contributes to declining prices through lower operating and maintenance costs, lower administrative costs, and other cost reductions. Federal Energy Regulatory Commission actions on open access and other changes for competitive markets enacted by some State public utility commissions are included in the projections, as noted above. Because other State actions that have yet to be formulated are not included, the projections do not represent a fully restructured electricity market. Legislative actions related to the electricity industry are discussed on page 11, and competitive electricity markets are discussed on page 20.

## Consumption

Total energy consumption is projected to increase from 94.9 to 120.9 quadrillion British thermal units (Btu) between 1998 and 2020, an average annual increase of 1.1 percent. Consumption in 2020 is 1 quadrillion Btu higher than projected in *AEO99*, primarily as a result of higher energy consumption for electricity generation and transportation.

Energy consumption in the residential and commercial sectors is projected to increase at average rates of 0.9 and 0.8 percent a year, respectively, led by growth in electricity use for a variety of equipment—telecommunications, computers, office equipment, and other appliances. In 2020, delivered residential energy demand is 12.8 quadrillion Btu, 0.3 quadrillion Btu lower than in *AEO99*, primarily because of a lower estimate for wood use in the Energy Information Administration's (EIA's) *Residential Energy Consumption Survey 1997*. Total demand is slightly higher, however, because more fuel is used to generate the electricity consumed in the sector. Higher projected energy intensity is offset by lower growth in the number of households. In the commercial sector, slightly lower energy intensity, particularly for lighting, leads to a slightly lower projection for delivered energy demand at 9.2 quadrillion Btu in 2020, 0.2 quadrillion Btu lower than in *AEO99*. As in the residential sector, primary energy demand in 2020 is slightly higher due to electricity losses.

Total demand in the industrial sector increases at an average rate of 0.9 percent a year, to 42.2 quadrillion Btu in 2020. Delivered energy demand is about 0.5 quadrillion Btu lower in 2020 than was projected in

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*AEO99* because of lower growth of coal use in industrial boilers and more recent data that indicate lower industrial consumption of natural gas.

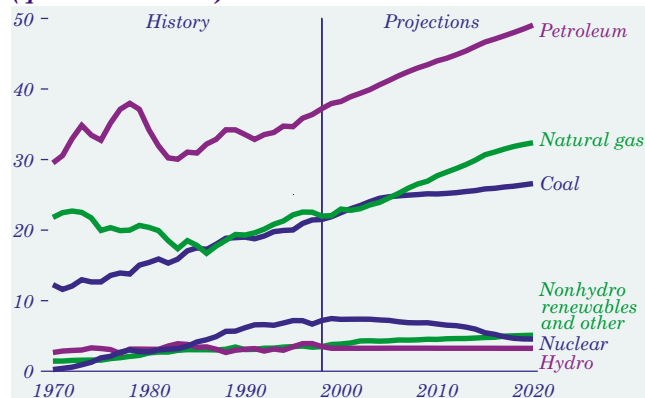
Transportation energy use grows at an average annual rate of 1.7 percent, to 37.5 quadrillion Btu in 2020, 0.7 quadrillion Btu higher than in *AEO99*. More travel is projected for light-duty vehicles, as recent data indicate that older drivers are driving more than previously assumed, slightly offset by lower assumed growth in driving by women. Compared with *AEO99*, lower gasoline prices and higher income reduce the expected average new car efficiency in 2020 from 32.1 to 31.6 miles per gallon.

*AEO2000*, like earlier *AEOs*, incorporates efficiency standards for new energy-using equipment in buildings and for motors, mandated through 1994 by the National Appliance Energy Conservation Act of 1987 and the Energy Policy Act of 1992. Several alternative cases examine the impacts of technology advances on the projections by assuming more and less rapid improvement of energy-efficient technologies in the end-use sectors relative to that projected in the reference case. Alternative efficiency standards are also analyzed for the buildings sectors.

Natural gas consumption increases in the forecast by an average of 1.8 percent a year (Figure 2). Increases are expected in all sectors, but the most rapid growth is for electricity generation, where natural gas use (excluding cogenerators) rises from 3.7 to 9.3 trillion cubic feet between 1998 and 2020. Total gas consumption in 2020 is lower than in *AEO99* by 0.8 trillion cubic feet, due to slightly lower projections for the commercial and industrial sectors.

Total coal consumption increases from 1,043 to 1,279 million tons a year between 1998 and 2020, an

**Figure 2. Energy consumption by fuel, 1970-2020 (quadrillion Btu)**



average annual increase of 0.9 percent, similar to the rate projected in *AEO99*. About 90 percent of the coal is used for electricity generation. Coal remains the primary fuel for generation, although its share of generation declines between 1998 and 2020.

Petroleum demand is projected to grow at an average rate of 1.3 percent a year through 2020, led by continued growth for transportation, which uses about 70 percent of the total. Increases in travel more than offset efficiency gains, and economic growth boosts petroleum use for freight and shipping through 2020. Total demand is higher than in *AEO99*, primarily due to higher light-duty vehicle travel.

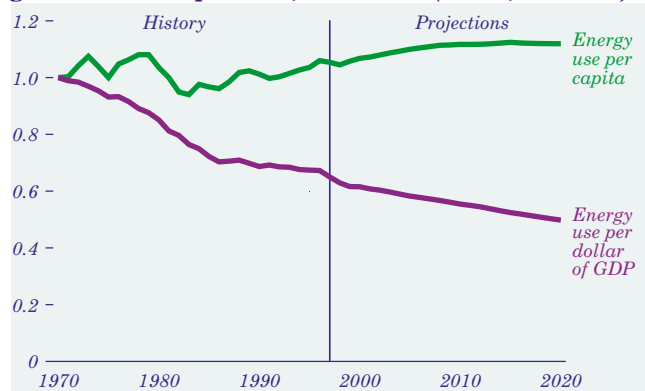
Renewable fuel consumption, including ethanol used for gasoline blending, increases at an average rate of 0.8 percent a year through 2020. About 60 percent of renewables are used for electricity generation and the rest for dispersed heating and cooling, industrial uses, and fuel blending. Renewable fuel use is 0.2 quadrillion Btu lower in 2020 than projected in *AEO99*, with slightly lower renewable electricity generation and residential wood demand.

Electricity consumption overall is projected to grow by 1.4 percent a year through 2020. Efficiency gains in the use of electricity partially offset the growth of new electricity-using equipment. Electricity demand is the same as in *AEO99*, with slightly lower commercial and transportation demand but higher industrial demand. Energy consumption for electricity generation is higher than in *AEO99* due to slower penetration of more efficient technologies, fewer retirements of nuclear and coal-fired power plants, and more generation from natural gas turbines.

## Energy Intensity

Energy intensity, measured as energy use per dollar of gross domestic product (GDP), has declined since 1970, particularly when energy prices have increased rapidly (Figure 3). Between 1970 and 1986, energy intensity declined at an average rate of 2.2 percent a year as the economy shifted to less energy-intensive industries and more efficient technologies. With smaller price increases and the growth of more energy-intensive industries, intensity declines moderated to an average of 1.0 percent a year between 1986 and 1998. Through 2020, energy intensity is projected to improve at an average rate of 1.1 percent a year as efficiency gains and structural shifts in the economy offset growth in demand for energy services.

**Figure 3. Energy use per capita and per dollar of gross domestic product, 1970-2020 (index, 1970 = 1)**



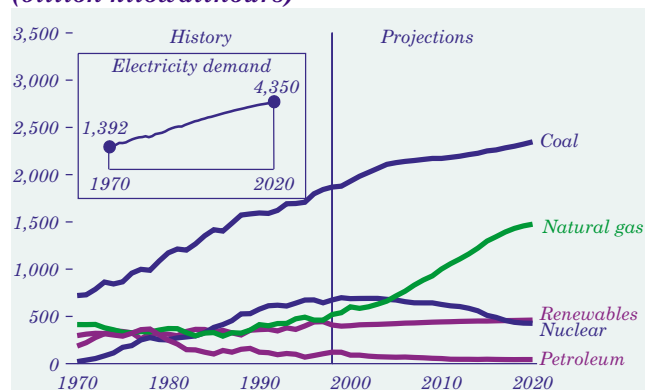
Energy use per person generally declined from 1970 through the mid-1980s, increasing when energy prices declined. Per capita energy use is expected to stabilize, as efficiency gains offset higher demand for energy services.

## Electricity Generation

Nuclear electricity generation declines over the projection period (Figure 4) but is higher in 2020 than was projected in *AEO99*, due to fewer plant retirements. Of the 97 gigawatts of nuclear capacity available in 1998, 40 gigawatts are projected to be retired by 2020, and no new plants are constructed. Nuclear plant retirements are based on analysis of their operating costs and the costs of life extension, compared with the costs of new generating capacity. Retirements are lower than in *AEO99* due to higher capital costs for fossil fuel replacement capacity, resulting in higher nuclear capacity and generation.

Generation from both natural gas and coal is projected to increase through 2020 to meet growing demand for electricity and offset the decline in

**Figure 4. Electricity generation by fuel, 1970-2020 (billion kilowatthours)**



nuclear power; however, the share of coal generation declines through 2020 because assumptions about electricity industry restructuring, such as higher cost of capital and shorter financial life of plants, favor the less capital-intensive and more efficient natural gas generation technologies. Compared with *AEO99*, coal generation is the same in 2020, and gas generation is lower because capital costs are projected to decline more slowly in the later years. The natural gas generation share increases from 14 percent to 31 percent between 1998 and 2020, a lower share than the 33 percent projected for 2020 in *AEO99*.

Renewable technologies penetrate slowly in the projections, because fossil fuel prices continue to be moderate. Also, electricity restructuring tends to favor the less capital-intensive natural gas technologies over coal and baseload renewables. Total renewable generation, including cogenerators, increases by 0.5 percent a year and is about 8 percent lower than in *AEO99*, primarily due to lower hydropower and biomass generation, offset in part by higher generation from wind and municipal solid waste. Hydropower is lower as a result of lower capacity factors and reduced capacity, and biomass generation is reduced because of its higher fuel costs. Hydropower declines through 2020 as regulatory actions limit capacity at existing sites and no large new sites are available for development. State renewable portfolio standards, where enacted, contribute to the growth of renewable generation.

## Production and Imports

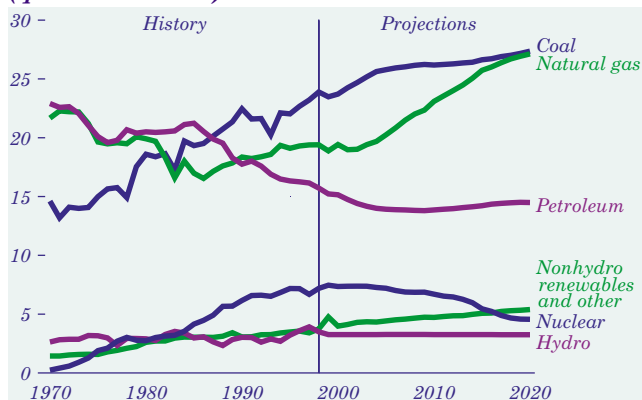
U.S. crude oil production declines at an average rate of 0.8 percent a year between 1998 and 2020 to a projected level of 5.3 million barrels per day. Advances in oil exploration and production technologies are insufficient to offset declining resources. Compared with *AEO99*, production is 0.3 million barrels a day higher in 2020, even though prices are slightly lower. A reevaluation of offshore resources contributes to rising oil production later in the projection period as oil prices increase. Increases in the production of natural gas plant liquids partially offset the decline in crude oil production through 2020 (Figure 5).

Falling production and rising demand increase petroleum imports through 2020 (Figure 6). The share of petroleum consumption met by net imports rises from 52 percent in 1998 (measured in barrels per day) to 64 percent in 2020. In 2020, the share is slightly lower than the 65-percent share in *AEO99*,

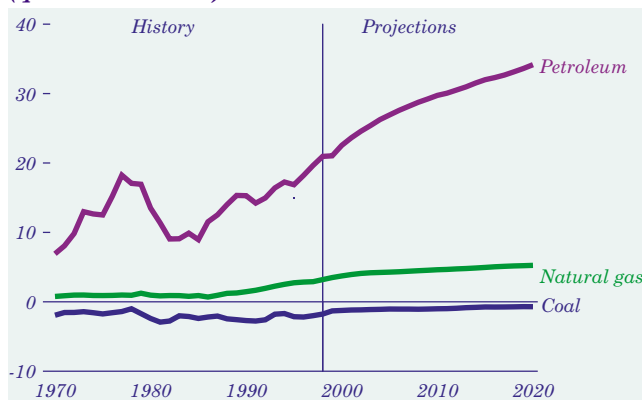


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**Figure 5. Energy production by fuel, 1970-2020 (quadrillion Btu)**



**Figure 6. Net energy imports by fuel, 1970-2020 (quadrillion Btu)**



although it is as much as 3 percentage points higher in 2005 as a result of lower domestic production.

In *AEO2000*, natural gas production is projected to increase from 18.9 trillion cubic feet in 1998 to 26.4 trillion cubic feet in 2020—an average rate of 1.5 percent a year—to meet growing demand for natural gas. Net imports of natural gas, primarily from Canada, also increase from 3.1 to 5.1 trillion cubic feet between 1998 and 2020. Pipeline capacity from Canada and capacity utilization rates increase to satisfy demand growth. Net imports of liquefied natural gas also increase, to 0.3 trillion cubic feet in 2020. Natural gas production is projected to be 1 trillion cubic feet lower in 2020 than projected in *AEO99*, due to lower demand and slightly higher imports.

Coal production increases from 1,128 million tons in 1998 to 1,316 million tons in 2020, an average of 0.7 percent a year, to meet rising domestic demand. In 2020, export demand is lower than in *AEO99* by 35 million tons. European imports are lower for environmental reasons, and exports from Australia are

higher. As a result, U.S. coal production in 2020 is 42 million tons lower than projected in *AEO99*.

Renewable energy production grows from 6.7 to 8.0 quadrillion Btu between 1998 and 2020, with growth in electricity generation from geothermal and wind energy, biomass, and municipal solid waste generation, more use of biomass in the industrial sector, and more ethanol use. Slightly lower renewable generation, mostly hydropower, and lower residential wood demand reduce renewable energy production slightly from *AEO99*, although the *AEO2000* projections add commercial wood consumption based on EIA's *State Energy Data Report 1996*.

## Carbon Emissions

Carbon emissions from energy use are projected to increase by an average of 1.3 percent a year through 2020, from 1,485 million metric tons in 1998 to 1,787 million metric tons in 2010 and 1,979 million in 2020 (Figure 7). Emissions in 2020 are higher by only 4 million metric tons than in *AEO99*. Although energy demand is higher in 2020 because of higher projected economic growth, travel, and fuel consumption for electricity generation, higher nuclear generation and more rapid efficiency improvements moderate the growth in emissions.

The Climate Change Action Plan (CCAP) was developed to stabilize greenhouse gas emissions in 2000 at 1990 levels. In 1990, energy-related carbon emissions were 1,345 million metric tons. *AEO2000* includes the impacts of CCAP provisions, including Climate Challenge and Climate Wise, which foster voluntary reductions in emissions by electric utilities and industry, but no new carbon reduction policies are incorporated. Carbon emissions and the Kyoto Protocol are discussed on pages 37 and 40.

**Figure 7. U.S. carbon emissions by sector and fuel, 1990-2020 (million metric tons)**

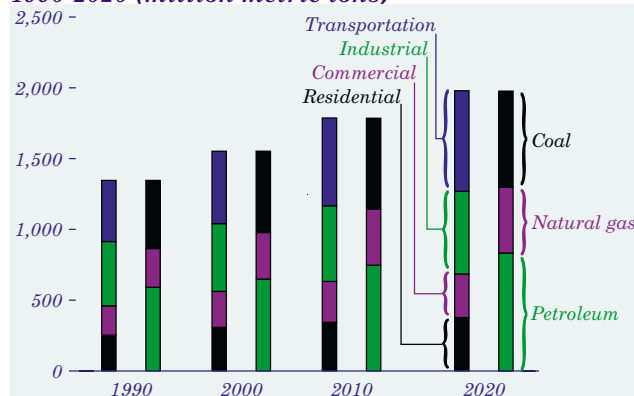


Table 1. Summary of results for five cases

Sensitivity Factors	1997	1998	2020				
			Reference	Low Economic Growth	High Economic Growth	Low World Oil Price	High World Oil Price
Primary Production (quadrillion Btu)							
Petroleum . . . . .	16.23	15.73	14.49	14.14	15.44	13.18	16.12
Natural Gas. . . . .	19.43	19.40	27.13	25.70	27.98	26.97	27.26
Coal. . . . .	23.28	23.89	27.36	26.14	29.62	26.90	27.43
Nuclear Power . . . . .	6.71	7.19	4.56	4.56	4.70	4.51	4.63
Renewable Energy . . . . .	7.00	6.67	7.98	7.77	8.40	7.90	8.06
Other. . . . .	0.66	0.57	0.66	0.66	0.68	0.59	0.73
<b>Total Primary Production . . . . .</b>	<b>73.30</b>	<b>73.46</b>	<b>82.18</b>	<b>78.98</b>	<b>86.82</b>	<b>80.06</b>	<b>84.23</b>
Net Imports (quadrillion Btu)							
Petroleum (including SPR) . . . . .	19.65	20.95	34.15	30.30	37.36	38.35	30.87
Natural Gas. . . . .	2.90	3.20	5.25	4.59	5.62	5.15	5.18
Coal/Other (- indicates export) . . . . .	-1.66	-1.46	-0.50	-0.55	-0.38	-0.50	-0.49
<b>Total Net Imports . . . . .</b>	<b>20.89</b>	<b>22.69</b>	<b>38.91</b>	<b>34.35</b>	<b>42.60</b>	<b>43.00</b>	<b>35.56</b>
Discrepancy . . . . .	-0.22	1.27	0.14	0.04	0.06	0.26	-0.09
Consumption (quadrillion Btu)							
Petroleum Products . . . . .	36.43	37.21	49.05	44.99	53.27	51.73	47.71
Natural Gas. . . . .	22.60	21.99	32.38	30.28	33.61	32.11	32.44
Coal. . . . .	21.34	21.50	26.60	25.32	28.98	26.15	26.68
Nuclear Power . . . . .	6.71	7.19	4.56	4.56	4.70	4.51	4.63
Renewable Energy . . . . .	7.00	6.67	7.99	7.78	8.42	7.92	8.08
Other. . . . .	0.33	0.32	0.36	0.34	0.38	0.37	0.34
<b>Total Consumption . . . . .</b>	<b>94.41</b>	<b>94.88</b>	<b>120.95</b>	<b>113.28</b>	<b>129.36</b>	<b>122.79</b>	<b>119.88</b>
Prices (1998 dollars)							
World Oil Price (dollars per barrel). . . . .	18.71	12.10	22.04	20.99	23.11	14.90	28.04
Domestic Natural Gas at Wellhead (dollars per thousand cubic feet). . . . .	2.39	1.96	2.81	2.40	3.27	2.68	2.87
Domestic Coal at Minemouth (dollars per short ton) . . . . .	18.32	17.51	12.54	12.40	12.58	12.38	12.53
Average Electricity Price (cents per kilowatthour). . . . .	6.9	6.7	5.8	5.5	6.1	5.8	5.9
Economic Indicators							
Real Gross Domestic Product (billion 1992 dollars) . . . . .	7,270	7,552	12,179	10,870	13,413	12,205	12,151
(annual change, 1998-2020). . . . .	—	—	2.2%	1.7%	2.6%	2.2%	2.2%
GDP Implicit Price Deflator (index, 1992=1.00) . . . . .	1.12	1.13	1.86	2.11	1.63	1.86	1.86
(annual change, 1998-2020). . . . .	—	—	2.3%	2.9%	1.7%	2.3%	2.3%
Real Disposable Personal Income (billion 1992 dollars) . . . . .	5,183	5,348	9,008	8,281	9,679	9,037	8,974
(annual change, 1998-2020). . . . .	—	—	2.4%	2.0%	2.7%	2.4%	2.4%
Index of Manufacturing Gross Output (index, 1987=1.00) . . . . .	1.365	1.411	2.160	1.972	2.483	2.166	2.158
(annual change, 1998-2020). . . . .	—	—	2.0%	1.5%	2.6%	2.0%	2.0%
Energy Intensity							
(thousand Btu per 1992 dollar of GDP) . . . . .	12.99	12.57	9.94	10.43	9.65	10.07	9.87
(annual change, 1998-2020) . . . . .	—	—	-1.1%	-0.8%	-1.2%	-1.0%	-1.1%
Carbon Emissions							
(million metric tons) . . . . .	1,479	1,485	1,979	1,851	2,126	2,019	1,956
(annual change, 1998-2020) . . . . .	—	—	1.3%	1.0%	1.6%	1.4%	1.3%

Notes: Specific assumptions underlying the alternative cases are defined in the Economic Activity and International Oil Markets sections beginning on page 48. Quantities are derived from historical volumes and assumed thermal conversion factors. Other production includes liquid hydrogen, methanol, supplemental natural gas, and some inputs to refineries. Net imports of petroleum include crude oil, petroleum products, unfinished oils, alcohols, ethers, and blending components. Other net imports include coal coke and electricity. Some refinery inputs appear as petroleum product consumption. Other consumption includes net electricity imports, liquid hydrogen, and methanol.

Sources: Tables A1, A19, A20, B1, B19, B20, C1, C19, and C20.